



MARKSCHEME

November 2012

CHEMISTRY

Standard Level

Paper 3

21 pages

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Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options [**2 x 20 marks**]. Maximum total = [**40 marks**].

1. A markscheme often has more marking points than the total allows. This is intentional.
2. Each marking point has a separate line and the end is shown by means of a semicolon (;).
3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.
4. Words in brackets () in the markscheme are not necessary to gain the mark.
5. Words that are underlined are essential for the mark.
6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.
7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).
8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.
11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme, similarly, if the formula is specifically asked for, unless directed otherwise in the markscheme do not award a mark for a correct name.
12. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.
13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

- A1.** (a) *Monochromator:*
allows only a narrow band/one frequency/wavelength/wavenumber (of IR radiation) to pass through;

Splitter:

splits the (infrared) light into two beams (with the same wavelength);

Reference:

absorbance/transmittance (of the reference) compared with/subtracted from absorbance/transmittance of sample / (the reference is) used to set the baseline / compare with sample/current / compensation for solvent / *OWTTE*;

[3]

- (b) detector/sensor/photodiode/photomultiplier;

[1]

- A2.** (a) *Bonds present: [2 max]*

Wavenumber / cm^{-1}	Bond
2850–3000	C–H
(3200–3600)	(hydrogen bonding of) O–H group(s) / oxygen–hydrogen / alcohol;
(1050–1410)	C–O/carbon–oxygen <u>single</u> bond;

Bonds absent: [1 max]

Wavenumber / cm^{-1}	Bond
(1700–1750)	C=O/carbonyl/carbon–oxygen <u>double</u> bond / CHO/aldehyde / COOH/carboxyl;

[3]

Accept other bonds/groups (C≡C/alkyne, etc.) even if they do not present in any of the three molecules.

No credit if atoms other than C, H or O are involved.

Award marks for functional group/bond names and ignore wavenumbers.

- (b) OH/hydroxyl/alcohol;

Accept ^+OH .

[1]

- (c) propan-1-ol/ $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$;

Accept “alcohol”.

[1]

- (d) 4;

Accept ECF from (c) – if propanoic acid/propanal = 3 peaks.

[1]

A3. (a) uses no ionizing radiation / uses low-energy radio waves / radio waves safer than x-rays / *OWTTE*; [1]
 Accept “does not damage body tissue”.

(b) MRI is (usually) a proton NMR/¹H NMR;
 (the states of) protons/hydrogen atoms in water/lipids/carbohydrates/proteins/
 different (chemical) environments are detected;
 different organs have different water concentration;
 (strong) magnetic field **and** radio waves/frequency are used;
 (by focusing the scanner on different parts of the body) three-dimensional/3-D
 images of (organs in) the body are produced / *OWTTE*; [3 max]

A4. (a) *Qualitative:*
 identification of an unknown substance / identify presence/verify purity of an individual substance / determination of the qualitative composition of a mixture / *OWTTE*;
Quantitative:
 measurement of the concentration/amount/level of a substance in a solution/mixture/biological material / determination of the ratio of components/percentage composition of a mixture / *OWTTE*; [2]
 Accept other general or specific uses.

(b) components dissolve in solvent/mobile phase;
 components adsorb onto stationary phase/SiO₂;
 components have different affinities for stationary phase / different solubility in mobile phase;
 distribution/partition between a stationary phase and a mobile phase;
 components move only when they are in the mobile phase / components don't move when they are in/on the stationary phase / *OWTTE*;
 more soluble/less adsorbed components elute earlier / less soluble/better adsorbed component elute later / *OWTTE*; [4 max]
 Accept silica/alumina etc. instead of stationary phase.

Option B — Human biochemistry

B1. (a)

<i>Function and</i>	<i>Example</i>
(primary source of) energy and	glucose;
(long-term) storage/reserve of energy and	glycogen
precursors/components of enzymes/RNA/ DNA/ATP/biologically important molecules and	ribose/deoxyribose

[2 max]

Award [1 max] if two functions without examples or two examples without functions are stated.

(b) (plant) material/cellulose which is (mainly) indigestible/not hydrolysed (by human enzymes) / *OWTTE*;

[1]

(c) provides bulk to the diet;
reduces appetite/intake of excessive food / prevents obesity;
prevents constipation / facilitates regular elimination / accelerates passage of food through digestive system;
regulates blood sugar / reduces the risk of diabetes;
reduces risk of hemorrhoids/bleeding of rectum wall/Crohn's disease/bowel cancer/disorders/IBS;
Accept other examples.

[3 max]

B2. (a) Saturated:

octanoic / $C_7H_{15}COOH/CH_3(CH_2)_6COOH$ /

lauric / $C_{11}H_{23}COOH/CH_3(CH_2)_{10}COOH$ /

palmitic / $C_{15}H_{31}COOH/CH_3(CH_2)_{14}COOH$ /

stearic / $C_{17}H_{35}COOH/CH_3(CH_2)_{16}COOH$;

Mono-unsaturated:

oleic / $C_{17}H_{33}COOH/CH_3(CH_2)_7CH=CH(CH_2)_7COOH$;

Poly-unsaturated:

linoleic / $C_{17}H_{31}COOH/CH_3(CH_2)_4(CH=CHCH_2)_2(CH_2)_6COOH$ /

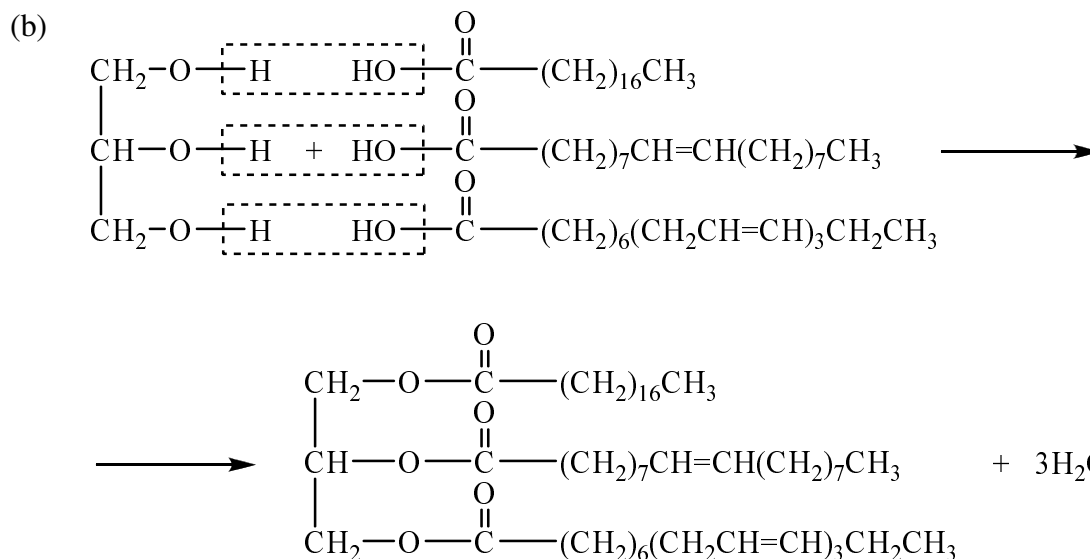
linolenic / $C_{17}H_{29}COOH/CH_3CH_2(CH=CHCH_2)_3(CH_2)_6COOH$;

[3]

Accept name or formula.

Accept other correct examples of fatty acids.

Accept systematic names instead of trivial names.



This scheme is only one of many possible examples.

the release of three molecules of water;

correct structure of all three ester groups;

Accept more condensed structural formulas.

Ester group must be written correctly, glycerol-OOC-R (not glycerol-COO-R).

Do not penalize for minor mistakes in the hydrocarbon chains or the use of R.

[2]

- (c) (i) phospholipids **and** steroids;

Do not accept cholesterol/other specific examples.

[1]

- (ii) all three types of lipids are (predominantly) hydrophobic/non-polar/consist mostly of hydrocarbon fragments;

triglycerides and (most) phospholipids contain (a fragment of) glycerol;

steroids are (poly)cyclic compounds/contain (several) rings;

phospholipids contain phosphate (group);

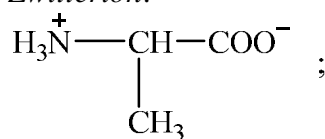
triglycerides and phospholipids are esters;

[2 max]

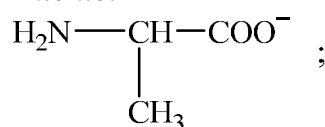
Allow phosphoric acid/phosphorus instead of phosphate in phospholipids.

Allow cholesterol is (poly)cyclic compound/contains (several) rings as ECF from (i).

B3. (a) *Zwitterion:*



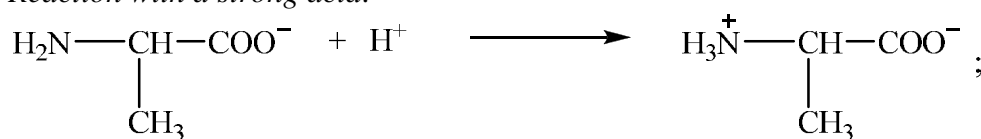
Anionic:



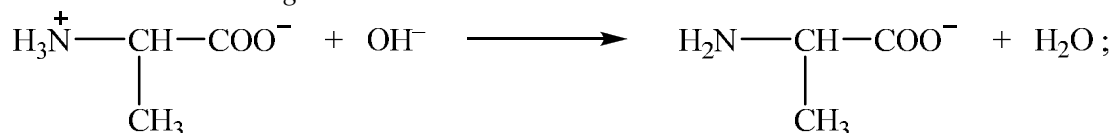
[2]

If a different 2-amino acid is used instead of alanine, penalize it once only in the paper.

(b) *Reaction with a strong acid:*



Reaction with a strong base:



[2]

Accept molecular formulas of a strong acid/base and the salt of amino acid.

Do not award marks for structures/equations with incorrect or missing charges.

(c) primary structure the sequence/order of amino acids **and** secondary structure regular/repeating folding/coiling of (amino acid) chains/ α -helix/ β -pleated sheet; primary structure covalent/peptide bonds **and** secondary structure hydrogen bonds;

Accept an annotated drawing or diagram for M1.

OR

primary structure the sequence/order of amino acids **and** covalent/peptide bonds; secondary structure regular/repeating folding/coiling of (amino acid) chains **and** hydrogen bonds;

[2]

Option C — Chemistry in industry and technology

C1. (a) iron ore as source of iron;

Accept named ore e.g. haematite/siderite/Fe₂O₃/magnetite/Fe₃O₄.

limestone/CaCO₃ to remove (acidic) impurities / formation of slag;
 coke/carbon/methane as reducing agent / to provide heat/high temperature;
 air/oxygen/methane to form CO for reduction / supply oxygen for combustion
 of coke;

[3 max]

Do not award mark for methane twice.

Award [1 max] for identifying three raw materials only without stating purposes.

(b) Fe₂O₃ + 3CO → 2Fe + 3CO₂ ;

Fe₂O₃ + 3C → 2Fe + 3CO ;

Fe₃O₄ + 4H₂ → 3Fe + 4H₂O ;

FeO + CO → Fe + CO₂ ;

[2 max]

Penalize incorrect balancing of equations once only.

Accept any other correct relevant equation.

(c) CaO + SiO₂ → CaSiO₃ / CaO + Al₂O₃ → Ca(AlO₂)₂ / CaAl₂O₄ ;

[1]

Accept any other correct relevant equation.

(d) reduce the carbon content / heating in an oxygen convertor;

annealing / by heating and cooling slowly;

[2]

C2. *Steam cracking:*

homogeneous;

Catalytic cracking:

heterogeneous;

Hydrocracking:

heterogeneous;

[3]

C3. (a) (i) **A;** [1]

(ii) **A;** [1]

(iii) **B;** [1]

(b) closely packed molecules with crystalline structure;

(plasticizers) separate the PVC molecules/polymer chains / disrupt crystalline structure;

decrease/weaken intermolecular forces/intermolecular dipole-dipole interactions/
van der Waals'/London Dispersion;

Do not accept mention of H-bonding

makes it (PVC) softer/more flexible/more easily moulded;

[3 max]

C4. selectivity – does the catalyst give a good yield of the desired compound / *OWTTE*;
efficiency – how much faster does the reaction occur/reach equilibrium / *OWTTE*;
economic – cost / how long the catalyst will last / how easily is it poisoned / *OWTTE*;
environmental impact – toxicity / regeneration / recyclability/ease of separation of
catalyst from reaction mixture / *OWTTE*;
versatility – ability to work under a range of conditions / ability to work with a range of
substances / *OWTTE*;

[3 max]

Award [1 max] for any three correct factors without explanation.

Option D — Medicines and drugs

- D1.** (a) drug design/discovery/screening/identifying lead compound;
preparation of analogues through combinatorial chemistry;
characterization of the new compound / in vitro testing / drug
formulation/delivery/stability studies;
pre-clinical (toxicology and pharmacokinetics) tests / tests on animals/bacteria/
cell cultures / LD₅₀ / *OWTTE*;
clinical tests/tests on humans;
ED₅₀ to show improvements over existing drugs / *OWTTE*; **[3 max]**
Penalize for incorrect order once only.
- (b) oral – by mouth / swallowing pills/powders / drinking liquids/mixtures / *OWTTE*;
inhalation – administering drugs into respiratory tract / inhaling gases/vapours/
sprays/powders;
rectal – introducing drugs into the rectum/colon via the anus / using suppositories/
enemas; **[2 max]**
transdermal – diffusion through the skin/skin patches/ointments/therapeutic baths;
Accept other methods/variations with appropriate descriptions.
Award [1 max] if only two correct names or two correct descriptions are given.
- (c) irregular/interrupted treatment allows more bacteria to survive (and mutate) /
failure to complete full course / *OWTTE*;
surviving bacteria develop/pass on resistance (to the drug); **[2]**
Do not accept superbugs.

- D2.** (a) *Aspirin:*
(increased risk of) stomach bleeding;
- Diazepam:*
heavy sedation/unconsciousness/coma / suppresses CNS; [2]
- (b) (i) *Dichromate(VI) ions:*
accept electrons **and** (thus) reduced;
- Ethanol:*
loses electrons **and** (thus) oxidized; [2]
Award [1 max] for stating that dichromate is reduced and ethanol is oxidized without reference to electrons.
No ECF from dichromate to ethanol.
- (ii) ethanol is oxidized by (atmospheric) oxygen;
oxidation at the anode / reduction at the cathode;
electrical current is produced (by the reaction);
the current/anode potential is proportional/related to the ethanol level/
concentration; [2 max]
Accept emf.
- (iii) C-H bonds (in ethanol) (absorb IR radiation) / (absorption/peak at) 2950 cm^{-1} ;
Do not award M1 if other bonds are mentioned or mentioned in addition to C-H.
(intensity of) absorption/transmittance is proportional to/depends on the
ethanol level / *OWTTE*; [2]
- D3.** (a) tertiary; [1]
- (b) *Short-term effects: [2 max]*
euphoria/alertness/concentration/relaxation/reduced anxiety/enhanced memory;
higher blood pressure;
reduced appetite;
reduced urine output;
pain-killing effect;
- Long-term effects: [2 max]*
(coronary) thrombosis/heart disorders/higher blood pressure;
(peptic) ulcers;
teratogenic properties/increased risk of birth defects;
weight loss (due to reduced appetite); [4 max]
- Do not accept cancer / lung disease.*
Do not accept "higher blood pressure" for both.

Option E — Environmental chemistry

E1. (a) volcano eruption/activity / lightning / microbial activity; [1]

(b) $S + O_2 \rightarrow SO_2$;
 $SO_2 + H_2O \rightarrow H_2SO_3$; [2]

(c) washing of coal/natural gas / fluidized bed combustion / remove sulfur before/during the burning;
 scrubbing exhaust gases;
 using catalytic converters;
 low-S diesel / fuel switching / use of alternative energy sources/wind/solar/tidal energy;
 reduction in energy consumption;
Accept specific examples of energy saving (e.g. use of bicycles instead of cars).
 use lime/formula of a reasonable base on rivers/lakes/soils to neutralize the acid; [4 max]
Allow other methods/solutions.
Award [2 max] for adverse effects of acid deposition on environment.

E2. (a) pesticides – farming;
 organic matter – sewage / food processing / detergents / oil industry / wood industry;
 dioxins – waste incineration/emissions from industry/power plants;
 polychlorinated biphenyls/PCBs – (electronic/chemical) industry;
 nitrates / NO_3^- – fertilizers/farming;
 phosphates / PO_4^{3-} / HPO_4^{2-} / $H_2PO_4^-$ – detergents/fertilizers/farming; [2 max]
Accept specific applications/processes.
Award [1 max] for two correct primary pollutants without sources.

(b) *Primary stage:*
 sedimentation/flotation/filtration **and** particulates/solid pollutants/oil/grease;

Secondary stage:
 aerobic biodegradation/treatment with micro-organisms and oxygen/activated sludge process **and** organic matter/named component of organic matter/ammonia/nitrogen compounds;

Tertiary stage:
 biological removal of nitrogen/phosphorus compounds / treatment with chemicals / chemical precipitation / disinfection (with halogens/ozone/UV) **and** ammonia/nitrates/phosphates/heavy metals/micro-organisms/viruses/pathogens; [3]
Award [1 max] if three processes are identified but no substances are given.
Award [2 max] if the stages are described in incorrect order.

E3. (a)

Reaction	Environment
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$	aerobic
$CH_3COO^- + H_2O \rightarrow CH_4 + HCO_3^-$	anaerobic
$2CH_2O + SO_4^{2-} \rightarrow 2CO_2 + H_2S + 2OH^-$	anaerobic
$2CH_2O + O_2 + 2OH^- \rightarrow 2HCOO^- + 2H_2O$	aerobic

[2]

Award [2] for all four correct, award [1] for two or three correct.

- (b) eutrophication – (unrestricted) growth of plankton/algae/micro-organisms/plants;
 thermal pollution – lower solubility of oxygen/O₂ in hot water;
 decrease in population/extinction of fish/aquatic animals/complex plants /
 replacement of native species with new (anoxia-tolerant/thermophilic) organisms;

[3]

E4. landfills require more space/land / are unsightly/ugly;

incineration reduces volume/mass of waste;

landfills require (long-term) site maintenance/need to settle/produce methane;

incineration produces stable residue;

landfills pollute ground water/incineration pollutes atmosphere;

landfills can be expanded easily/incineration plants have limited capacity;

[3 max]

Accept statements of relative cost of landfills and incineration if they are justified with comments about the availability/cost of land.

Accept converse statements for M1 and M2.

Option F — Food chemistry

- F1.** (a) (i) ester; [1]
- (ii) carboxylic acid / carboxyl; [1]
Accept alkanoic acid.
Accept formulas.
- (b) chocolate melts easily/ solid state needs to be maintained in hot climates;
 more crystalline fats / higher melting point/ more saturated fats used / longer chain /
 more hydrogenated/*trans* fats used;
 intermolecular forces stronger; [3]
Accept converse arguments.
- F2.** (a) *Type of rancidity:*
 oxidative (rancidity) / photo-oxidation;
- Functional group:*
carbon-carbon double bond/C=C / alkene; [2]
- (b) storage;
 in fridge/freezer / low temperature reduces rate of reaction / absence of light / low
 moisture levels;
- processing;
 to limit lipase activity / keeping moisture levels low;
- packaging;
 excluding air/oxygen by using an inert gas / hermetic packaging to exclude
 oxygen / eliminating air from the head space / light-proof materials;
- additives;
 sodium hydrogensulfite or citric acid to prevent oxidation (and non-enzymic
 browning) / tocopherols to prevent free-radical oxidation / anti-oxidants; [4 max]
- Each method and correct example scores [2 marks], up to [4 max].*
Two correct methods alone score [2].
Two correct examples alone score [2].
If examples don't match methods [3 max].

F3. (a) A;
 in acid solution $[H^+]$ high / **A** protonated; [2]
No ECF possible.

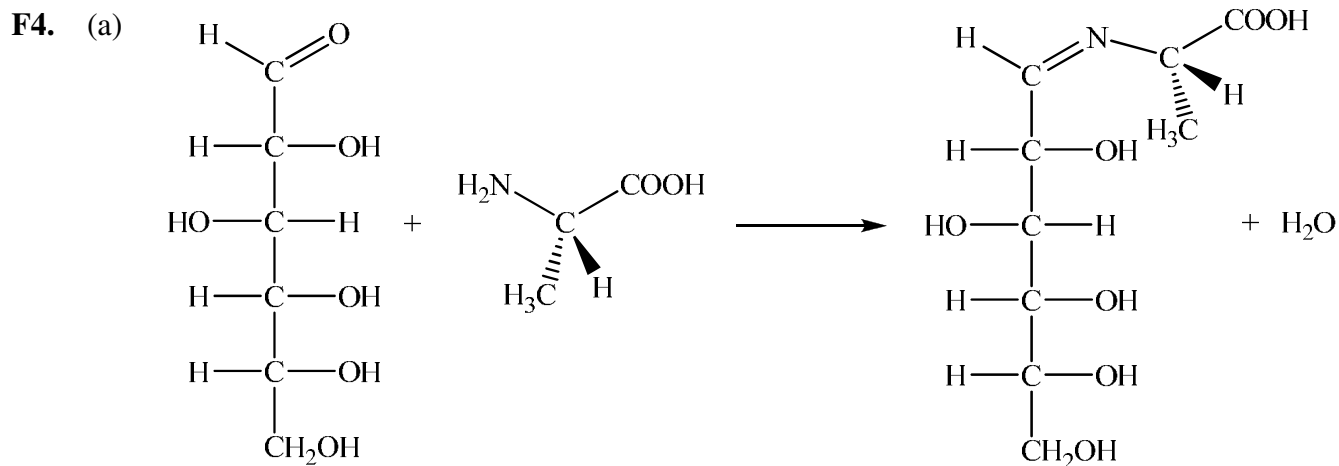
(b) flavonoids;
 peptides (tumerin);
 phenols;
 porphyrins;
 tocopherols;
 vitamins (A/C/E);
 carotenes; [2 max]
Accept specific examples of any of the above. Only accept Vitamin once.

(c) red light reflected / *OWTTE*;
 other colours/complementary colour of red/green absorbed / *OWTTE*;

OR

the complementary colour of red is absorbed;
 all others reflected; [2]

Do not accept "opposite" colour.
Do not accept "repel".



double bond between C_1 of glucose and N of alanine;
 water/ H_2O ; [2]
Accept 2-D representations.

(b) milk contains high quantities of lysine / *OWTTE*; [1]
Allow "milk contains both amino acids and (reducing) sugars".

Option G — Further organic chemistry

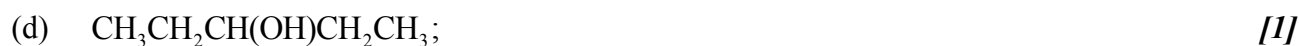
Only penalize missing or misplaced H atoms once in the questions.



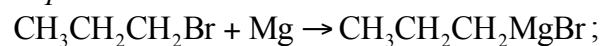
Allow more detailed formulas/reactions throughout the question.



Accept correct IUPAC name of organic product in (a).

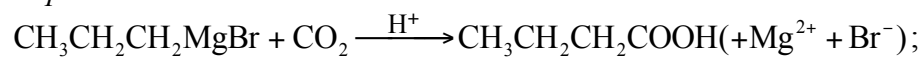


(e) Step 1:



dry/anhydrous (solvents/reactants);

Step 2:



H^+ /acid (catalyst);

Accept H_2O /water instead of H^+ .

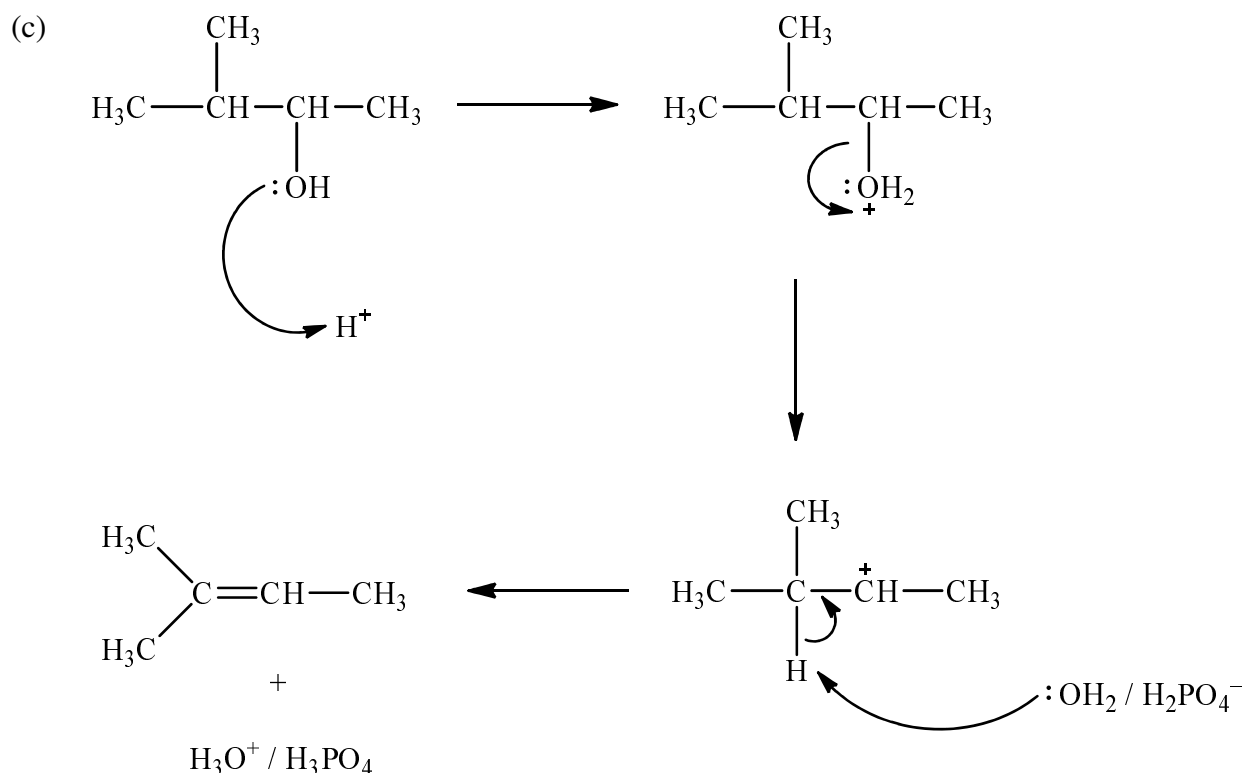
Award [1 max] for conditions.

[3 max]

- G2. (a) $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{CH}_3 / (\text{CH}_3)_2\text{CHCH}(\text{OH})\text{CH}_3$;
 $(\text{CH}_3)_2\text{CBrCH}_2\text{CH}_3$; [2]
 Allow more detailed formulas.

- (b) Step 1:
 elimination/E / dehydration;

- Step 2:
 (electrophilic) addition/ A_E ; [2]



curly arrow going from lone pair on O to H^+ ;
 representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;

curly arrow going from lone pair on O of $\text{H}_2\text{O}/\text{H}_2\text{PO}_4^-$ to H **and** curly arrow going from $\text{C}-\text{H}$ bond to $\text{C}-\text{C}^+$ (to form $\text{C}=\text{C}$);
 No mark awarded if C^+ is not represented.

formulation of organic product **and** $\text{H}_3\text{O}^+ / \text{H}_3\text{PO}_4$; [4]
 Award [3 max] if 3-methylbut-1-ene is formed.

- G3.** (a) increases acidity / *OWTTE*;
nitro groups are electron acceptors / nitro groups withdraw/pull electrons/have negative inductive effect;
(acceptors) increase O–H bond polarity / increase δ^+ on H / decrease O–H bond strength / favour dissociation of O–H bond / stabilises phenolate ion / *OWTTE*; [3]
- (b) (3,5-dinitrophenol is) more acidic than phenol but less acidic than 2,4,6-trinitrophenol / *OWTTE*; [1]
- (c) 6.7; [1]
Accept any value in the range 0.43 –7.14.
-